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ON QUALITY BREEDING OF THE FIELD PEA AND ITS RESULTS

AT THE DEPARTMENT OF PLANT BREEDING, AGRICULTURAL RESEARCH CENTRE, JOKIOINEN

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PELTOHERNEEN LAATUJALOSTUKSESTA JA SEN TULOKSISTA MAATALOUSKOELAITOKSEN KASVINJALOSTUSOSASTOLLA JOKIOISISSA

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On quality breeding of the field pea and its results at the Department of Plant Breeding, Agricultural Research Centre, Jokioinen

Vilho A. Pesola

At the Department of Plant Breeding, Agricultural Research Centre, the breeding of field peas has been going on over 30 years, ever since 1924 (1918), and several varieties of green and white seed peas, as well as one fodder pea variety (Pesola 1931, 1935a, 1935b, 1938, 1939, 1942a, 1942b) have been developed and marketed. In the breeding of peas attention has been concentrated chiefly on the growing properties, such as the seed and straw yields, the growing time (the earliness), the length and strength of stem, special characteristics in flowering, susceptibility to plant diseases and pests, etc. (Inkilä 1948). Considerable attention has also been given to the cooking properties, the taste and quality. The following points in particular have been studied: the colour of the seed and its different shades, the size and shape of the seed, the protein content, the speed of cooking or softening and the taste. The following is a report on the observations and research made on the quality breeding of peas and on some of the results obtained.

Growing conditions and material

The investigations were principally carried out during the 5 years from 1950—54, on peas growing in the the experimental fields belonging to the Department of Plant Breeding, Agricultural Research Centre at Jokioinen. The soil in the fields consisted of heavy clay. According to the investigations made in 1951 (Vuorinen 1952), the pH value of the experimental fields was 5.5—6.0, the calcium content (Ca CO_3t per ha) 7—13, the quality of easily soluble phosphorus (as superphosphate kg. per ha) 90—190, the amount of potassium (as 40 %- potassium salt kg. per ha) 800—1 800, the humus content (humus %) 4—7. As the experimental fields were deficient in phosphoric acid, their condition was improved by copious additions of phosphoric acid fertilizers. In 1950—54 the fields were given 800—1 200 kg. of superphosphate annually, the amount of potassium salt (40 %) given per annum was 200 kg.

As regards the climatic conditions during the experimental years, it should be mentioned that in 1950, with the exception of July, the period of growth (May-September) had a smaller than normal rainfall. In 1951, May, June and July had, on an average, normal temperatures, whereas August and September were exceptionally warm. The entire period had a slighter rainfall than usual. In 1952, the period of growth was cooler than the average and almost normal as regards rainfall. In 1953, the period of growth was, with the exception of September, warmer than normal, and June, July and August had a heavier rainfall than normal. The period of growth was also warmer than normal in 1954. July and September had an exceptionally heavy rainfall.

The material comes from the results of the main experiments (Pk), where the test plots were 15 sq.m. in size with 6 replicates, or from the results of the preliminary experiments (Vka), where the test plots were 8 sq.m. in size, with 4 replicates. The numbers 2, 3, etc., indicate the different groups of the same experiment.

As regards the technical cultivation conditions, these were mainly the same as in ordinary practical cultivation and on the whole, they were similar each year.

The results of the tests and the research work appear in Tables 1 and 2, and show the following facts:

Line or variety and place of breeding. The following abbreviations are used: Jo = Jokioinen (= Department of Plant Breeding, Agricultural Research Centre). G = Gyllene Svalöf, E. M. = Early Market England, Exp. = Express, ToII = Torsdag II Svalöf, C = Concordia Svalöf, Mansh. K. = Mansholts Kortstroo, Holland, Au = Aune (Jo), Sin. = Sinikka (Jo), Koiv. = Koivisto (Jo), Lid. = Lidingö Sweden, Ad. = Adoptive Weibullsholm. There are 29 varieties or lines in the Table 2, and this represents only a small part of the material used in the tests. In addition to some important home and foreign varieties, the table includes a number of the newest lines developed by the Department of Plant Breeding at Jokioinen, in particular such varieties that have, in one way or another, proved to be valuable in breeding work and have in consequence been subject to relatively numerous tests and investigations.

The colour of the seed, which is green (vi), white (va) or some other colour and often variegated (ki).

The experimental years and their number (total number of years, and number of years during which protein determinations were made).

The crude protein content, as an absolute percentage, and as higher (+) or lower (—) than that of the standard variety (Torsdag II) in the same tests. The crude protein (in the following text referred to as

protein) determinations on the pea seeds (in the following text referred to as peas) were carried out at the Laboratory for Food Industry, State Institute for Technical Research, under the supervision of Mr. T. VEIJOLA, M.Sc. I hereby wish to express my gratitude to Mr. Veijola and the above Institute. The coefficient used in the protein determinations was 5.7.

The softening or cooking speed as the absolute time in minutes and the cooking speed as slower (+) or quicker (—) than that of the standard variety in the same tests.

Taste, using the scale 1—10, 10 being the best possible, and as better (+) or poorer (—) than the standard variety in the same tests.

Seed yield in ratio to the standard variety (kg. per ha), indicated by the figure 100. According to probability calculations, significant differences in the yields between the various varieties and lines can be ascertained only when the difference of the yield between two varieties is at least 8 %.

The number of growing days (earliness) as compared to the standard variety: growing time as shorter (—) or longer (+) than that of the standard variety. In Table 2 the varieties and lines are entered in their order of earliness, beginning with the earliest (3 days earlier than the standard variety) and ending with the latest (12 days later than the standard variety). A difference of some two weeks is represented between the earliest and the latest variety. The standard variety, Torsdag II, belongs to the medium early pea varieties (cf. PESOLA 1941) and can be cultivated all over our actual pea-growing area (below lat. 63°). Sinikka, for example, is among the late varieties. Its growing time is approximately the same as that of the Guldregn II oat, and this particular pea is, in fact, intended to be grown with oat varieties belonging to the Guldregn II time-class. As the Department of Plant Breeding in their breeding of peas has specially concentrated on developing a variety for human consumption which is suitable for cultivation with oats, and as the main oat varieties grown here are late or medium late, special attention has to be paid to pea breeds that are 5—10 days later than the Torsdag II, and that are strong and luxuriant in growth, as well as otherwise valuable. It should be mentioned that in the summers of 1953 and 1954, the latter halves of which, as has been pointed out, were cold and rainy, the Sinikka pea proved to be perhaps somewhat too late for the conditions prevailing at Jokioinen as was apparent particularly from the relative smallnes of the crop.

The weight of 1 000 seeds, determined from unsorted material.

The protein content

The author has earlier (PESOLA 1955) shown that the protein content of pea seeds is a varietal characteristic, apparently dependent on polymeric

Table 1. Quality and growing properties of the Torsdag II pea, at Jokioinen 1950—54.

Taulukko 1. Torstai II-herneen käyttö- ja viljelyominaisuuksia Jokioisissa v. 1950—54.

Year *Vuosi*	Test *Koe*	Protein % *Prot. %*	Softening in mins. *Pehmen. min.*	Taste (1—10) *Maku (1—10)*	Yield kg ha *Sato kg ha*	Vegetation period days *Aik. pv.*	Weight of 1 000 seeds g *1 000 s. p. g*
1950....	Pk 1	18.47	(185)	7.9	1 506	89	186
»	» 2	18.53	(185)	8.1	1 584	90	181
»	Vka 1	17.78	(260)	7.9	957	88	174
»	» 2	17.50	(170)	8.0	798	87	168
»	» 3	17.21	(220)	7.4	710	88	173
		17.90	(204)	7.9	1 111	88	176
		± 0.26	± 16	±0.1	± 182		
1951....	Pk 1		85	8.4	1 232	88	184
»	» 2		85	8.4	1 438	87	190
»	Vka 1		90	8.4	1 023	88	185
»	» 2		90	8.0	1 022	90	187
»	» 3		75	8.4	1 425	87	180
»	» 4		65	8.3	1 763	88	187
			82	8.3	1 317	88	186
			± 4	±0.1	± 116		
1952....	Pk 1	19.70	140	8.3	2 481	101	169
»	» 2	20.50	140	8.4	2 558	101	182
»	Vka 1	21.40	90	8.4	2 155	104	(164)
»	» 2	—	80	8.2	2 605	104	164
»	» 3	23.60	90	8.1	1 640	103	149
»	» 4	23.50	100	8.4	1 713	103	163
		21.74	107	8.3	2 192	103	165
		± 0.79	± 11	±0.1	± 175		
1953....	Pk 1	19.04	135	7.6	2 048	95	174
»	» 2	20.63	135	7.8	1 983	95	174
»	Vka 1	19.04	100	7.8	1 763	92	170
»	» 2	19.49	190	6.2	1 831	93	164
»	» 3	19.44	115	7.7	1 821	91	168
»	» 4	19.55	75	8.5	1 893	91	159
		19.53	125	7.6	1 890	93	168
		± 0.24	± 16	±0.3	± 44		
1954....	Pk 1	22.70	130	7.8	1 504	99	152
»	» 2	22.30	110	7.3	1 511	99	146
»	» 3	23.00	110	7.9	1 605	98	145
»	Vka 1	22.10	95	8.3	679	96	160
»	» 2	21.40	90	8.3	1 270	101	155
»	» 3	21.30	100	7.8	1 423	99	142
		22.15	106	7.9	1 332	99	150
		± 0.28	± 6	±0.2	± 138		
1950—54		20.33	105	8.0	1 568	94	169
		± 0.99	± 21	±0.1	± 203		

genes. Consequently, it can be improved by breeding. However, external factors, in particular soil and climatic conditions, also considerably affect

the protein content of the seeds (l. c. p. 126). In view of the use of peas as human nutrient, as well as for cattle fodder, a high protein content of the seeds is a valuable feature.

Table 1 shows that, during a 4-year period from altogether 22 tests the average protein content of the standard variety, Torsdag II, was 20.33 %, which can be considered moderate (PESOLA 1955). The protein content of Torsdag II varied in different years, which was apparently caused mainly by the climatic conditions prevailing during the growing season. The lowest average (17.90 %) protein content was reached in 1950, and the highest (22.15 %) in 1954. Variations can also be found in different experiments within the same year. Thus in 1952 for example, the lowest protein content (PK I) was 19.70 % and the highest 23.60 % (Vka 3). These variations appear to be caused mainly by differences in the soil in the various parts of the experimental field, and also partly, perhaps, by the conditions prevailing during the maturation of the pea in the field.

Table 2 shows the protein content of the different varieties and lines, both as an absolute figure and in comparison to the standard variety used in the same test. Whenever only one or two determinations are available, the value must naturally be considered as correspondingly uncertain.

If the varieties and lines with 3—4 determinations are arranged according to the relative grades of their protein content, we get the following (the figures in brackets indicate the protein content above or below that of the standard variety): Jo 04416 (+1.79), JO 04414 (+1.67), Ilo (+1.56), Artturi (+1.48), Kalle (+1.45), Sinikka (+1.27). Jo 05901 (+0.97), Jo 03490 (+0.83), Hohenheim (+0.81), Jo 03297 (+0.78), Jo 03737 (+0.73), Jo 04733 (+0.67), Jo 04404 (+0.43), Kloster (+0.34), Torsdag II (20.37 %), Paula (—0.17), Torsdag III (—0.18), Brio (—0.75), Jo 04312 (—1.06), Prof. Sauli (—1.49). The difference between the best and the worst is 3.28 %. The Jokioinen line 03315 from the year 1952 has the highet absolute protein content (24.7 %), while Prof. Sauli from the year 1950 has the lowest (16.13 %).

If we consider the standard errors of the mean figures, it seems proper to place the lines and varieties into three categories: a) protein content higher than of Torsdag II (at least 1 % higher), b protein content approximately equal to that of Torsdag II (maximum of 1 % above or below Torsdag II), c) protein content lower than that of Torsdag II (at least 1 % lower). We note that the best group includes some of the new lines of the Jokioinen Department and the varieties Ilo, Kalle, Sinikka and Hohenheim, the medium group includes Kloster, Paula, Torsdag III and Brio, and the poorest group contains one of the Department's new lines and Professor Sauli. In some cases the placing of a line in a particular group is questionable or owing to the relatively high standard error of the mean.

Table 2. Quality and growing pro-
All compared with

Taulukko 2. Herneiden käyttö- ja vilje-
(Kaikki verrattuna

Variety or line *Lajike tai linja*	Year *Vuosi*	Test years *Koevuosia*		Seed *Siem.*	Crude *Raaka-*
		Total *Kaikkiaan*	Protein determ. *Prot. määrit.*	Colour *Väri*	%
Jo 0715 (G. × E. M.) × Expr.	1950—53	4	3	Va	19.06
Jo 05994 (To II × Expr.)	1950—54	5	2	Vi	19.22
Torsdag II, Svalöf	1950—54	5	4	Va	20.33
Torsdag III, Svalöf	1950—54	4	3	Va	20.67
Jo 03745 (C. × Gyll. 0 674)	1950—54	5	2	Vi	21.56
Paula, Jokioinen	1950—53	4	2	Vi	20.54
Jo 07245 (Mansh. K. ½ Au)	1950—54	5	2	Vi	19.93
Jo 03737 (C. × Gyll.)	1950—54	5	4	Vi	20.95
Kalle, Tammisto	1950—54	5	4	Vi	21.83
Kloster, Weibullsholm	1950—53	4	4	Va	20.35
Jo 05901 (Sin. × Koiv.)	1950—54	5	4	Vi	21.32
Jo 04727 (Sin. × Lid.)	1950—54	5	1	Vi	23.10
Jo 04312 (Lid. × Martta)	1950—54	5	3	Vi	18.43
Jo 03273 (Sin. × Koiv.)	1950—54	5	1	Vi	22.80
Jo 04404 (Sin. × Ad.)	1950—54	5	3	Vi	22.80
Brio, Svalöf	1949—52	4	2	Ki	18.70
Jo 03403 (Paula × 028)	1950—54	5	1	Vi	22.80
Jo 04733 (Sin. × Lid.)	1950—54	5	4	Vi	20.76
Jo 04416 (Sin. × Ad.)	1950—54	5	4	Vi	21.37
Professori Sauli, Tammisto	1950—53	4	3	Vi	18.41
Jo 03490 (Sin. × Ilo)	1950—53	4	3	Vi	20.17
Artturi, Jokioinen	1949—52	4	3	Ki	21.72
Jo 03315 (Sin. × To II)	1950—53	4	2	Va	22.76
Jo 03297 (Sin. × To II)	1950—54	5	3	Vi	20.70
Ilo, Jokioinen	1948—52	5	4	Va	22.29
Hohenheim, Saksa	1949—52	4	4	Ki	21.97
Jo 04746 (Sin. × To II)	1950—54	5	2	Vi	20.56
Sinikka, Jokioinen	1950—54	5	4	Vi	21.53
Jo 04414 (Sin. × Ad.)	1950—54	5	4	Vi	21.92

Cooking or softening speed

The author has already paid attention to the cooking or softening speed of pea seeds in earlier investigations (e.g. PESOLA 1935 a etc.) It appeared that the softening property of the pea is another varietal characteristic, although it is also greatly affected by many external factors, such as climatic conditions, the soil, fertilization, the drying of the peas, the water in which they are boiled, etc. Problems arising in this connection have subsequently been studied extensively, especially in Sweden.

MATTSON (1946), in particular has thoroughly studied the softening of the pea (cf. also GELIN and SCHWANBOM 1943, MATTSON, ÅKERBERG, ERIKSSON, KOUTLER-ANDERSSON and VAHTRAS 1950, ÅKERBERG and BINGEFORS 1948). It appeared from Mattson's investigations that the

perties of peas at Jokioinen in 1950—54.
Torsdag II (± To II).

lyominaisuuksia Jokioisissa v. 1950—54.
Torstai II:en (± To II).

protein *prot.*	Softening *Pehmeneminen*		Taste *Maku*		Seed yield relative values To II = 100 *Siemensato suhdeluku To II = 100*	Vegetation period days + To II *Kasvuaj. pit. päiv.* ± *To II*	Weight of 1 000 seeds + To II *1 000 s. p. g* ± *To II*
± To II	Mins. *Min.*	± To II	Scale (1—10) *Ast. (1—10)*	± To II			
(+0.67±0.36)	87	— 5 (± 5)	8.2	±0.0 (±0.2)	106.0	— 3.0	+ 14
—1.35	176	+58 (±24)	7.4	—0.8 (±0.5)	107.6	— 2.0	+ 11
	105		8.0		1 568 kg	94	169
—0.18 (±0.19)	94	± 0 (± 2)	7.9	—0.3 (±0.2)	103.1	+ 0.2	± 0
—0.11	96	—13 (± 7)	8.9	+0.9 (±0.1)	108.6	+ 1.0	+ 14
—0.17	142	+ 5 (±25)	9.0	+1.1 (±0.3)	(110.5)	+ 2.0	+ 4
+0.93	169	+28 (±20)	8.4	+0.6 (±0.2)	100.6	+ 2.6	+ 14
+0.73 (±0.51)	89	—25 (±14)	8.9	+0.7 (±0.1)	103.9	+ 2.6	+ 15
+1.45 (±0.74)	117	—23 (±10)	8.7	+0.6 (±0.1)	98.2	+ 3.4	+ 12
+0.34 (±0.17)	83	—10 (± 6)	7.9	—0.3 (±0.1)	103.0	+ 4.0	+ 1
+0.97 (±0.63)	113	— 6 (±14)	8.9	+0.8 (±0.3)	115.0	+ 5.0	± 0
+0.80	85	—33 (±17)	9.0	+1.4 (±0.3)	111.8	+ 5.4	+ 18
—1.06 (±1.36)	106	— 8 (± 3)	8.7	+0.8 (±0.3)	112.5	+ 6.0	+ 10
+0.10	70	—26 (±11)	8.9	+1.2 (±0.1)	113.6	+ 6.0	+ 32
+0.43 (±0.38)	113	—13 (±11)	8.7	+0.5 (±0.4)	122.1	+ 6.0	+ 3
—0.75	293	+203	4.3	—4.0 (±0.5)	105.6	+ 6.0	+ 76
+0.10	91	—30 (±12)	8.7	+1.1 (±0.3)	107.7	+ 6.6	— 7
+0.67 (±0.26)	100	—18 (± 3)	8.8	+0.8 (±0.3)	123.7	+ 7.4	+ 6
+1.79 (±0.55)	111	— 8 (±10)	8.8	+0.7 (±0.2)	109.1	+ 7.6	— 1
—1.49 (±0.42)	73	—32 (±22)	9.7	+1.6 (±0.2)	85.1	+ 8.0	+ 69
+0.83 (±0.24)	100	—20 (±10)	9.0	+0.9 (±0.1)	115.5	+ 8.5	— 5
+1.48 (±1.43)	293	+203	4.1	—4.1 (±0.2)	(101.4)	+ 9.0	— 9
+1.69	70	—28 (±22)	8.1	+0.2 (±0.5)	113.8	+ 9.0	+ 12
+0.78 (±0.48)	69	—16 (± 3)	9.2	+1.3 (±0.2)	117.3	+ 9.2	+ 23
+1.56 (±0.24)	88	(— 3)	7.9	(+0.8) (±1.3)	111.9	+ 9.6	± 0
+0.81 (±0.34)	293	+203	4.1	—4.2 (±0.4)	99.4	+ 9.8	— 5
+2.10	88	—18 (±11)	9.0	+0.7 (±0.1)	107.6	+10.0	+ 10
+1.27 (±0.54)	104	—14 (± 8)	8.7	+0.7 (±0.3)	100.0	+11.0	+ 13
+1.67 (±0.64)	93	—25 (± 5)	8.6	+0.6 (±0.3)	104.1	+11.6	— 4

speed of softening is primarily dependent on the solubility of the pectin substances in the cell walls. The pectin substances decompose during cooking, causing the cells to break down. The solubility of the pectins, again, depends on the substances with which they are chemically combined. If these are saturated with sodium and potassium for example, the peas will cook quickly; if, on the other hand, they are saturated with calcium and magnesium, the peas cook slowly. However, the cooking properties of even such peas can be improved if the substance that precipitates calcium and magnesium is added. Phytin, an organic phosphoric acid, is such a substance and it is found in greater quantities in quick-cooking peas than in slow-cooking peas. The pH value also affects the speed of cooking to the extent that, when it is 4—5 the precipitating effect of the phytin on

the calcium and magnesium is insufficient, so the process of softening is then at its slowest. Mattson has discovered that peas that are slow to cook can most easily be improved by adding a mixture of di- and tribasic sodium phosphate to the water, but, at the most, not more than 9—10 g. mixture per kg. of the peas should be used.

Mattson's investigations have further confirmed the already known fact that, in certain cases, a very high lime content of the soil can have a harmful effect on the cooking properties of the pea, whereas a high phosphate and potassium content in particular can improve it (cf. Bjälfve 1944, 1947, Andersson and Åkerberg 1954 etc.).

At the Department of Plant Breeding, the experiments on the cooking of peas were made in accordance with the method that has been described earlier (Pesola 1935, p. 44), and which is again outlined here: The peas were dried outside, at first in the open, then under cover, after which they were stored at room temperature. In 1950, the peas were dried in a Dinesen drier. 60 g. of pea seeds from each variety and line were placed in cold water to soak overnight, each sample being put in a small enamel bowl and left there for 17 hours. In the morning, the bowls were placed on a stove heated with wood (in 1954 electric cookers were used). The bowls were shifted around on the stove, so as to give each one the same amount of heat. The time each lot of peas needed to reach the degree of softness required for ordinary cooking purpose, and the actual time of cooking (the time the peas were in boiling water) were noted down. — The cooking was done by the same person each year. — The water was rather soft (degree of hardness 2—3 on the German hardness scale). In the case of peas grown in 1953 and 1954 and belonging to the author's test material, softening determinations have been made at the State Institute for Technical Research, with an apparatus specially built for this purpose (cf. Mattson 1946); these investigations are not yet complete.

Table 1 presents the cooking times of the standard variety, Torsdag II, in different years and tests. Torsdag II needed (1951—54), on an average, 105 minutes to become soft. Only in 1951 did this pea cook almost as quickly (82 minutes) as it did, on an average, in the years mentioned above. In 1950, the pea took a particularly long time to cook: it needed 204 (170—260) minutes, or about 3—4 hours. The reason for this was examined in detail at the Department, but it never became quite clear. The most probable reason was that the peas had been overdried. It is no longer possible to find out what caused the peas in the three-year period 1952—54 to soften, on an average, much more slowly than in the five-year period 1930—34. Apparently it was not due to the phosphorus and lime contents of the soil, as the phosphoric acid and lime contents of the experimental fields were more favourable to the pea during the later period than during the earlier one.

It should also be noted that the cooking time of the pea can vary considerably in different experiments and tests groups in the same year. This was especially the case in 1952 and 1953. In this case, the real reason cannot lie in the soil or in climatic conditions. The differences may be primarily due to factors relating to the drying of the pea.

It is thus apparent that, as regards cooking time, the pea is particularly sensitive to various external influences. On the other hand, varietal differences may also be found, as can be seen from Table 2 and the following Table 3.

Table 3. The cooking or softening speed of the peas in minutes in relation to that of Torsdag II.
(Mean values, without the results from the year 1950).

Taulukko 3. Herneiden pehmenemisnopeus minuuteissa, suhteessa Torstai II:een. (Keskiarvot, ilman v:n 1950 tuloksia).

Variety	Mean ± To II	Variety	Mean ± To II	Variety	Mean
Jo 04727	—33	Jo 04746	—18	Ilo	— 3
Prof. Sauli	—32	Jo 03297	—16	Torsdag II	(105)
Jo 03403	—30	Sinikka	—14	Torsdag III	± 0
Jo 03315	—28	Jo 03745	—13	Paula	+ 5
Jl 03273	—26	Jo 04404	—13	Jo 07245	+ 28
Jo 04414	—25	Kloster	—10	Jo 05994	+ 58
Jo 03737	—25	Jo 04312	— 8	Hohenheim	+203
Kalle	—23	Jo 04416	— 8	Brio	+203
Jo 03490	—20	Jo 05901	- 6	Artturi	+203
Jo 04733	—18	Jo 0715	— 5		

The above table gives a picture of the varying cooking speeds of the different lines and varieties. Whereas Torsdag II required an average of 105 minutes, or 1 $^3/_4$ hours, to soften in the years 1951—54, the six fastest varieties took about 30 minutes less to soften and the slowest needed some 3.5 hours longer. All three varieties of fodder peas appear to be very much slower in cooking than the others. Also among the peas meant for human consumption, there are some that take 30—60 minutes longer to soften than Torsdag II does.

The lines and varieties fall naturally into three categories with regard to their boiling properties, as was also the case with regard to their protein content (in some cases the placing of a line in a particular group is questionable owing to the relatively high standard error of the mean):

1. The varieties that cook faster than Torsdag II (at least 10 minutes faster).

2. Cooking speed approximately the same as that of Torsdag II (10 minutes faster — 10 minutes slower than Torsdag II).

3. Varieties that clearly require a longer cooking time than Torsdag II (over 10 minutes slower than Torsdag II).

It appears from the table that the first, and the best, group includes, in addition to the best lines of the Department, Professor Sauli, Kalle and Sinikka, while the second group, again, includes Kloster Con the border line of group 1), Ilo, Torsdag III and Paula. The shortest absolute cooking time, 50—55 minutes, or less than an hour was taken by Jo 03315 (1953), Jo 03297 (1951), Professor Sauli (1951) and Jo 03273 (1951). The longest cooking time among the peas intended for human consumption, 260 minutes or over 4 hours, belongs to the Jokioinen line 05994 (1952). The Jokioinen line 07245 (in 1952 and 1953) required over three hours.

The slow cooking of the fodder peas is notable. Further investigations will reveal whether this is due to a low phytin-content, as may be assumed on the basis of MATTSON's investigations already referred to.

The differences between the typical varieties and lines are statistically significant.

From the above it is apparent that the cooking or softening speed of the pea is a varietal characteristic due to hereditary factors, as has already been shown (PESOLA 1935, ÅKERBERG 1951, etc.), although this characteristic is very susceptible to the influence of external factors. Some investigations, especially those carried out in Sweden, throw light on the nature of these hereditary factors, and further research will no doubt reveal new features in this question.

Taste

The taste of the pea has so far received comparatively little attention from research workers. The author (PESOLA 1935) has earlier dealt with this question and has come to the conclusion that there are distinct varietal differences in taste. ÅKERBERG (1951) refers to the value of research on taste in the breeding of peas.

Research work on the taste of peas is complicated, firstly, by the fact that it is impossible to define the taste exactly, and secondly, by the fact that tastes vary greatly, and »matters of taste cannot be disputed». In the following an attempt has been made to base the evaluations of taste on the general taste that prevails in Finland, which the author (PESOLA 1935, p. 46) defines as follows: As regards the taste of peas it is possible to make a division into three »taste groups» (with regard to the soft boiled pea, although in the main the same points apply to fresh peas also). A pea can be more or less distinctly sweet, or it can be »tasteless», or its taste

can be more or less clearly bitter. The importance of the taste of the pea depends to some extent on its use. With peas that are used for fodder, the taste is presumably of no importance. If the pea is used for soup, which is usually made with meat or pork, the taste of the pea in itself probably does not have much significance. As is well known, even fodder peas are suitable for this purpose, and some people even prefer the white »tasteless» peas to the green slightly sweet peas when making soup. In pea stews, the slightly sweet (green) peas are obviously preferable. In Finland, the sweet taste is generally preferred, and as this taste is usually more evident in green peas than in the white peas, it seems to be the main reason why green peas, as a rule, are more expensive to buy than the white ones. In the taste evaluations of the Department of Plant Breeding, these above-mentioned lines have been followed.

The taste experiments on peas, results of which are presented in Tables 1 and 2 and in the following Table, were carried out as follows (Pesola 1935, p. 46—47).

The test material consisted of peas which had been boiled until soft in the cooking speed tests, then salted slightly and tasted warm. In the evaluation, the scale 1—10 was used, 10 being given to the slightly sweet pea with a refined taste, 4 being awarded to a pea with a clearly bitter taste, and 7 to a pea which was »tasteless», i.e. with neither a sweet nor a bitter taste. Each time there were 5—6 men and women acting as tasters. They judged the peas independently of each other, and without knowing which pea they were tasting. The figures in the table are the mean values of the marks given. Conformity in judgment was, as a rule, noticeable.

It should also, perhaps, be pointed out that the results in the tastings at the Department seem to correpond to general popular use and taste. Earlier (Pesola 1935, p. 41), the well known Svalöf green pea Concordia was awarded the taste mark 9.6 (mean value, = excellent) by the tasters, and the Department's green variety Koivisto was awarded the mark 8.9. In practice, both have been very popular owing to their taste and, in the case of Koivisto, because of its speedy cooking as well, which was also to be seen in the cooking tests at the Department. On the other hand, the white Torsdag II pea, with its more undistinguished taste (7.5, Pesola 1935), has been sold at a lower price than the two previously mentioned green pea varieties. The variety Artturi, with its poor taste (5.9, Pesola 1935), is not apparently used as a cooking pea at all. This can, of course, be due also to its slow cooking properties.

The following Table 4 presents the tastes of the pea varieties and lines as compared to the standard variety, Torsdag II, in the years 1950—54:

Table 4. The taste of peas, scale 1—10, as compared to Torsdag II.

Taulukko 4. Herneiden maku, 1—10-asteikossa, verrattuna Torstai II:n makuun.

Variety	± To II	Variety	± To II	Variety	± To II
Prof. Sauli	+1.6	Jo 04733	+0.8	Jo 0715	±0
Jo 04727	+1.4	Jo 04416	+0.7	Torsdag III	—0.3
Jo 03297	+1.3	Sinikka	+0.7	Kloster	—0.3
Jo 03273	+1.2	Jo 04746	+0.7	Jo 05994	—0.8
Paula	+1.1	Jo 03737	+.07	Brio	4.0
Jo 03403	+1.1	Jo 07245	+0.6	Artturi	—4.1
Jo 03745	+0.9	Kalle	+0.6	Hohenheim	—4.1
Jo 03490	+0.9	Jo 04414	+0.6		
Ilo	(+0.8)	Jo 04404	+0.5		
Jo 05901	+0.8	Jo 03315	+0.2		
Jo 04312	+0.8	Torsdag II	8.0		

It is apparent from Table 1 that, from 29 tests during the 5 test years. the mean taste mark for Torsdag II is 8.0, the mean values of different years varying between 7.6 (1953) and 8.3 (1951 und 1952), in fact within rather narrow limits. It is not possible to find out what caused the comparatively poor taste in Torsdag II in 1953, and its comparatively good taste in 1951 and 1952. The great variations in the taste of this pea (6.2—8.5) in the year 1953 are noteworthy. This apparently has some connection with the varying cooking speeds of the pea in the different test groups in that year (cf. above). Probably the Torsdag II which was awarded a poor mark in taste that year had not softened sufficiently in spite of its long cooking time, and this fact may have influenced the taste mark.

During the 5-year period 1930—34, Torsdag II was awarded the taste mark 7.5 (mean value) and during the 5-year period 1950—54 it was awarded the mark 8.0. This is a difference which cannot depend only on chance, but there must be a definite reason for it. It is, however, practically impossible to determine this reason. It is not impossible to presume that, as different people were acting as tasters during these two periods, the »tastelessness» of Torsdag II, which apparently remained the same all the time, was valued slightly differently by each test group. It is mainly due to this that Torsdag II was a stronger competitor in taste in the years 1950—54 than in 1930—34.

It is worth noticing that Sinikka was awarded the mark 8.7 and Paula 9.0 in each of the 5-year periods, although the group of tasters had changed. Presumably this can be considered a proof of the suitability of the research method. Both Sinikka and Paula have, in practice, become popular as cooking peas. Artturi appeared to have a poor taste in each test period.

It is evident from Table 2 that the absolute taste marks of the pea varieties and lines vary between 9.7—4.1 while the values as compared to

Torsdag II vary from + 1.6—-4.2. Professor Sauli is awarded the highest taste mark, 9.7 (+ 1.6). In the tests in 1930—34, Concordia reached the same class (9.6).

In addition to the above-mentioned Paula and Sinikka, Kalle and several of the Jokioinen lines also proved to be tasty and superior to Torsdag II. Kloster and Torsdag III, as well as the Jokioinen lines 03315 and 0715 for example, remain with Torsdag II in the mediocre group, and all three fodder peas form a group by themselves, with a distinctly poorer taste. The poor taste of the fodder peas has already appeared convincingly obvious earlier (Pesola 1935).

It is obvious from the above discussion, and from the statistical analysis of the experimental data that the taste of peas is clearly a varietal characteristic, i. e. a characteristic dependent on hereditary factors, although several external factors, such as the degree of softness, possibly the composition of the skin, etc., may exercise a considerable influence. The question of the possible reasons for the differing tastes in peas will have to be left open until further investigations are made. It is possible that the poor taste of the fodder peas may be caused by some of the factors which produce their slow cooking properties.

The colour of the seed

As has already been mentioned, in Finland green peas are preferred to the white ones. This may be due to the fact that green peas common in Finland mostly cook more quickly and are better in taste than the white peas. Among the breeding material of the author there have, however, been white peas with cooking properties almost fully equal to those of the best green peas.

Of the green peas, those with dark green colour which does not easily change, are the most popular. It is well known that the green colour of the pea seed can, under the influence of light, dampness, etc., turn lighter, for example, in such a way that one half of the seed is lighter than the other. The crop thus becomes variegated and its marketing value diminishes. It has been established that the tendency to »lighten» varies with different pea varieties. For example, the green colour of Concordia is more lasting than that of Sinikka and Paula. It has not yet been explained what hereditary factors cause this variation in the lasting quality of the green colour. In breeding, the permanency of the green colour has to be considered.

Yields, growing time, and weight of 1 000 seeds

In this paper it is considered desirable to pay particular attention to the qualitative characteristics of the pea, such as its crude protein content,

its speed of cooking (softening) and its taste. As these investigations are connected with the breeding of peas, and as the qualitative characteristics mentioned above reach full importance only when they are combined with valuable cultivation properties, in the first place, a good crop, a suitable growing time and an adequate size of seed, Tables 1 and 2 also include figures referring to these points, which have already been mentioned at the beginning of this paper.

A few explanatory remarks may, however, be in place here.

According to experiments conducted in Sweden (cf. HAMMARLUND 1931, ELIASSON and JACOBSON 1946), Norway (VIK 1945) and Finland (PESOLA 1939), Torsdag II is a variety with a comparatively good yield.

According to Table 1, the years 1952 and 1953 were relatively good pea years (yields 2 192 kg. and 1 890 kg. per ha), while the year 1950, on the other hand, was a particularly poor one (1 111 kg. per ha). The preliminary test in particular yielded a poor crop in 1950. As regards the Jokioinen lines included in Table 2, these appear among the first in yield capacity in the field experiments.

In the grouping according to earliness of spring cereals and peas, made by the author previously (PESOLA 1941), Torsdag II was included in the medium early group and Sinikka in the late group. In the years (1929—35) on which this grouping is based, Torsdag II required, on an average, 89 days to ripen, and Sinikka took 100 days. In the years under investigation, Torsdag II needed, on an average, 94 days, or 5 days longer, to ripen than during the above 7-year period. This longer average time is particularly due to the summer of 1952, when the pea ripened slowly (103 days). During the 5-year period 1950—54, Sinikka required on an average, 105 days to ripen or, compared to Torsdag II, only 3 days more than the average time in 1930—34.

To the medium early pea lines belong those that are, at the most, 3 days earlier or later than Torsdag II, to the medium late lines belong those that are 4—9 days later than Torsdag II, and to the late lines those that are at least 10 days later than Torsdag II.

In our entire pea-growing area, the medium early varieties and lines are most suitable for growing as the sole crops (alone). In the breeding of the medium late and late peas, the strength and luxuriance of the stem has also been considered, so as to make the peas suitable for growing with oats, as in the case of fodder peas. Thus medium late peas can be grown together with medium late or medium early oat varieties (e.g. Tammi, Orion III) and, again, late pea varieties can be grown with late oat varieties (e.g. Sisu, Sol II, Juha, Guldregn II). Sometimes when the end of the summer is rainy (e.g. as in 1954), the lateness of the Sinikka pea may prove detrimental in Jokioinen conditions (approx. lat. 61° N.), and a somewhat

shorter growing time is required to assure the normal ripening of the pea and a reasonable yield during summers that are climatically unfavourable.

As regards the weight of 1 000 seeds, that of the variety Torsdag II (169 g. on an average in 1950—54) may be considered suitable in our country, when the pea is grown alone, though it can be still higher, preferably not more than 200 g. (cf. Pesola 1935, p. 42). When the pea is grown mixed with oats, the seed of the pea can easily be even smaller, so the costs of sowing become correspondingly smaller.

Discussion

In view of what has been said above, and on the basis of Tables 1 and 2, it is possible to present the following facts:

White peas

In accordance with the prevalent taste in Finland, attention has been concentrated mainly on the breeding of green peas. At an earlier stage, however, white peas were included in the tests to a considerable extent, though these have since been gradually eliminated, and the Jokioinen Department has marketed only one variety, Ilo (1941). The early line 0715 and the late line 03315 were indeed ready for marketing some years ago, but, because of their white colour, were not acceptable for this purpose. However, they were later sent to Sweden to be experimented on. Together with the white Torsdag II, the tests included Swedish white peas, of which two, Torsdag III and Kloster, are presented in Table 2. The experiment reveals that at Jokioinen Torsdag III greatly resembled Torsdag II, both as regards its cultivation and its cooking and taste properties, while Kloster is slightly (4 days) later than Torsdag II (cf. Gelin 1948), with a somewhat higher protein content and a somewhat faster cooking speed (cf. Gelin 1948, Strand 1953, Bingefors and Jönsson 1954). The Jokioinen line 0715 resembles Torsdag II in taste and speed of softening, but has a better yield, being, in addition, 3 days earlier than Torsdag II. In the group of early peas, Jo 0715 is undoubtly slightly more valueble than Torsdag II. The late Jokoinen line 03315 can be primarily compared to the relatively valuable Ilo pea with regard to its growing, cooking and taste properties.

Green peas

The Jokioinen Paula pea, which belongs to the medium early category with regard to its growing time (+ 2 days), has a mediocre crude protein content and cooking speed, and a very good taste. It is a variety

that yields an abundant crop and is suitable as regards the size of the seed (cf. PESOLA 1942a and b). The Tammisto Kalle pea has a higher protein content and a faster cooking speed than Paula, but its taste is not quite so good. It is two days later than Paula, and its yield at Jokioinen was not quite so good as that of Paula. Professor Sauli can be placed in the top class with regard to its cooking speed and its taste, but its protein content is exceptionally low, and in yield it is clearly behind the standard variety. Professor Sauli belongs to the medium late varieties. The late Sinikka has valuable protein, taste, and cooking properties. In cool and rainy summers Sinikka is perhaps too late for the conditions prevailing at Jokioinen, in the district near Turku and in the Åland Islands, however, it is quite suitable. A couple of summers with cold and rainy weather towards the end, had a diminishing effect on the average yield of Sinikka during the five years from 1950—54. Sinikka's relative yield was then only 100.0, i. e. exactly the same as that of Torsdag II, whereas in the 7-year period 1931—38, it achieved an average ratio of 133 (PESOLA 1939). Sinikka's strong and luxuriant stem is specially to be mentioned, as it makes this pea suitable for growing with oats.

Of the new Jokioinen m e d i u m e a r l y l i n e s, Jo 03737 (a cross between Concordia and Gyllene) might be mentioned as an example with a high protein content, a fast softening speed, a good taste and a good yield, being at least equal to Torsdag II.

If we put the m e d i u m l a t e l i n e s in order of earliness, first of all we get Jo 05901 (from the cross Sinikka × Koivisto), which combines an excellent yield with comparatively valuable cooking and taste properties. An apparently even more valuable line is Jo 04727 (Sinikka × Lidingö), which belongs to the top class with regard to softening speed and taste, has a high protein content and a yield in a class with the previous line. The size of the seed is greater than in the case of Torsdag II, yet it is not too big. The line Jo 04312 (Lidingö × Martta) is also rather valuable as regards its taste and softening speed. The line Jo 03273 (Sinikka × Koivisto) is excellent in taste and speed of softening, has a relatively high protein content and yields a good crop. Its seed is exceptionally large. Jo 03403 (Paula × 028) is very valuable as regards its taste and softening speed. It is a line with a good yield and small-sized seeds. Jo 04733 (Sinikka × Lidingö) is one of the most promising combinations of growing, cooking, and taste properties. Jo 04416 (Sinikka × Adoptive) has a very high protein content and is certainly not among the poorest lines even in other respects. Jo 03490 (Sinikka × Ilo) is also a comparatively promising line.

Of the l a t e l i n e s, we can recommend only those that are earlier than Sinikka. One of these is Jo 03297 (Sinikka × Torsdag II), which

is a very valuable line as regards both its growing, cooking and taste properties. On the other hand, the line Jo 04414 (Sinikka × Torsdag II) can hardly be considered an improvement on Sinikka.

It appears from the above that, as a result of the work of the Plant Breeding Department, there are now several lines of peas belonging to different categories of earliness, to the medium early, the medium late and the late groups, and representing successful combinations of growing, cooking, and taste properties. A decision will be taken in the near future as to which of these will be grown in larger quantities in order to replace the Paula, Kalle and Sinikka peas on the market.

The f o d d e r p e a s included in the table, Brio, Hohenheim and Artturi, are very similar in taste and cooking properties, and very poor. The Brio pea has a low crude protein content and a large sized seed to its disadvantage. Artturi has possibly a higher protein content than Hohenheim, and the growing properties of these two varieties are about equal. It should be mentioned that in the 7-year period 1931—38, Artturi reached a higher yield ratio (110) than in the 3-year period stated here.

Summary

The following summary can be made on the basis of what has been said in this paper:

The crude protein content, the speed of softening and the taste of pea seeds are varietal characteristics, i. e. characteristics due to hereditary factors, but which are, however, greatly influenced by such external factors as soil, fertilization, climatic conditions during the period of growth, etc.

In the pea breeding work conducted at the Department of Plant Breeding, Agricultural Research Centre, considerable attention has been devoted to the qualitative properties of the pea mentioned above, and, by crossings, several lines have been produced in which valuable qualitative properties and favourable growing properties (in the first place a good yield, and a suitable growing time and size of seed) are successfully combined, and which show that progress has been made in this combination breeding.

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Selostus

Peltoherneen laatujalostuksesta ja sen tuloksista maatalouskoelaitoksen kasvinjalostusosastolla Jokioisissa

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Herneiden siementen raakaproteiinipitoisuus, pehmenemisnopeus ja maku ilmenevät lajikeominaisuuksina s. o. perinnöllisistä tekijöistä johtuvina ominaisuuksina, mutta niihin vaikuttavat suuresti myös ulkoiset olosuhteet kuten maaperän laatu, lannoitus, kasvukauden sääsuhteet jne.

Maatalouskoelaitoksen kasvinjalostusosastolla Jokioisissa suoritetussa herneenjalostustyössä, jossa on kiinnitetty melkoista huomiota edellä mainittuihin herneen käyttöominaisuuksiin (laatuun) on risteystietä luotu useita linjoja, joissa arvokkaat käyttöominaisuudet ja edulliset viljelyominaisuudet (lähinnä hyvä sato, asianmukainen kasvuajan pituus ja sovelias siemenen koko) ovat onnistuneesti yhdistyneinä ja jotka osoittavat, että tässä yhdistelmäjalostustyössä on päästy eteenpäin.